



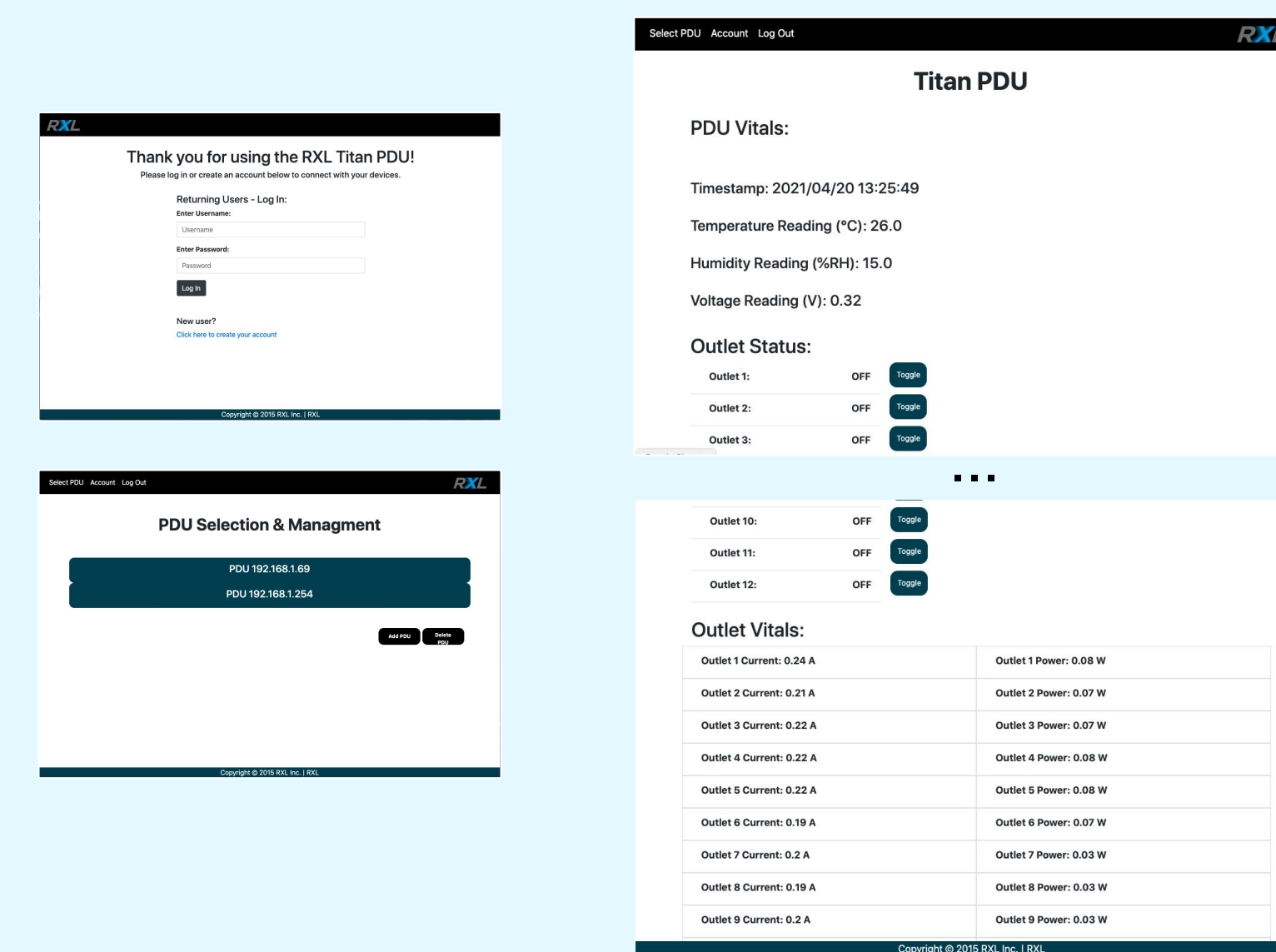
### Product Summary

The Titan Power Distribution Unit (Titan PDU) is a breakout product intended to facilitate RXL's expansion into the power distribution market. This new product line, custom designed to integrate with the server racks RXL is currently known for, is specifically created with data centers in mind, and each unit can reliably power up to 12 servers at a time with single phase 120 VAC. To make monitoring and controlling individual servers easy and efficient, our design boasts both in person and remote user interfaces. Both our in person LCD interface and our website interface allow users to monitor system vitals including temperature, humidity, voltage, as well as outlet-specific current and power. Outlets can also be turned on and off individually from either user interface, allowing precise, individual control of each server connected to the system. The remote user interface supports multiple PDUs per user, an essential feature for server house applications.

### Team Positively, Definitely, Ultimately

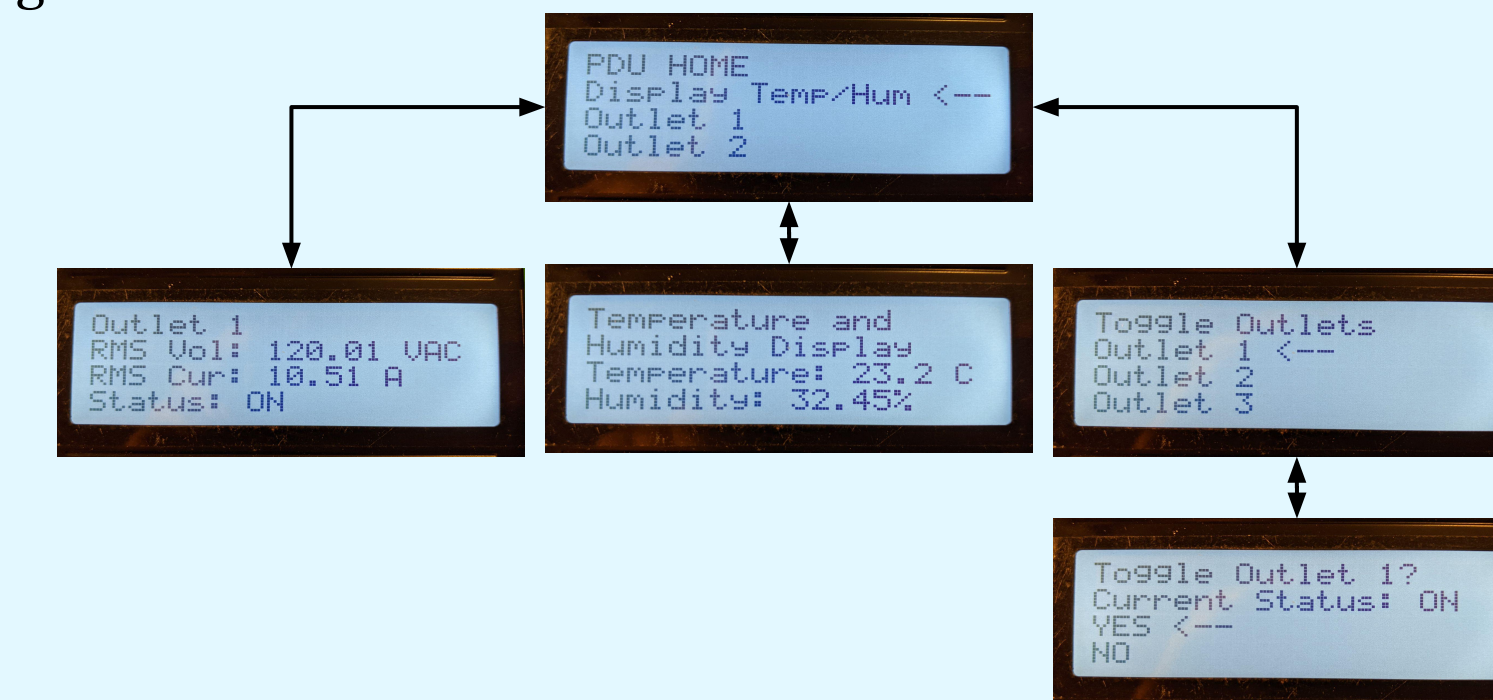
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Tristan Santiago, Madison Chodikov, Zach Wilson

### User Interfaces



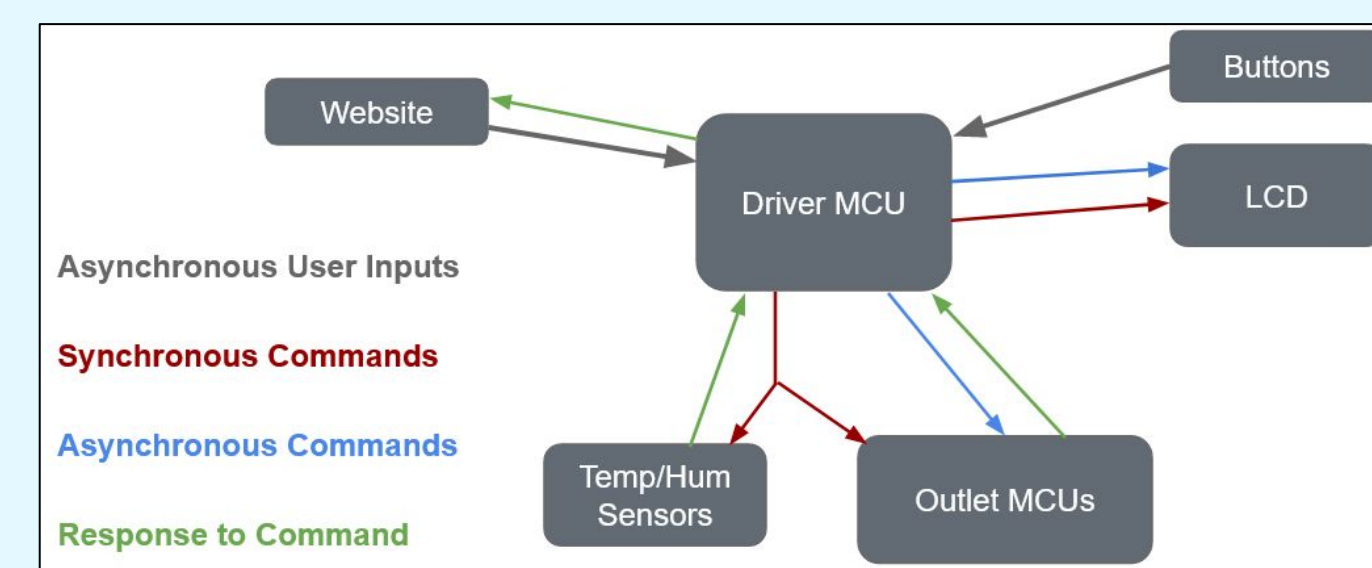
- Remote UI:**
- LAN
  - Supports registration of multiple PDUs per user
  - Displays PDU vitals
    - Temperature
    - Humidity
  - Voltage, current, and power measurements
    - Input voltage
    - Per outlet
      - Current
      - Power (apparent)
  - Outlet Status and Control
    - Indicated on LED and in LCD menu
    - Outlet on/off control

- In Person UI:**
- Use buttons for navigation and performing actions
  - Displays PDU vitals
    - Temperature
    - Humidity
  - Voltage, current, and power measurements
    - Input voltage
    - Per outlet
      - Current
      - Power (apparent)
  - Outlet Status and Control
    - Indicated on LED and in LCD menu
    - Outlet on/off control



### Software Overview

- Firmware on PDU communicates with networked server.
- PDU communicates with internet router via wired Ethernet.
- Data and commands are transferred to and from outlets via I2C.
- Temperature and humidity sensing performed onboard PDU.

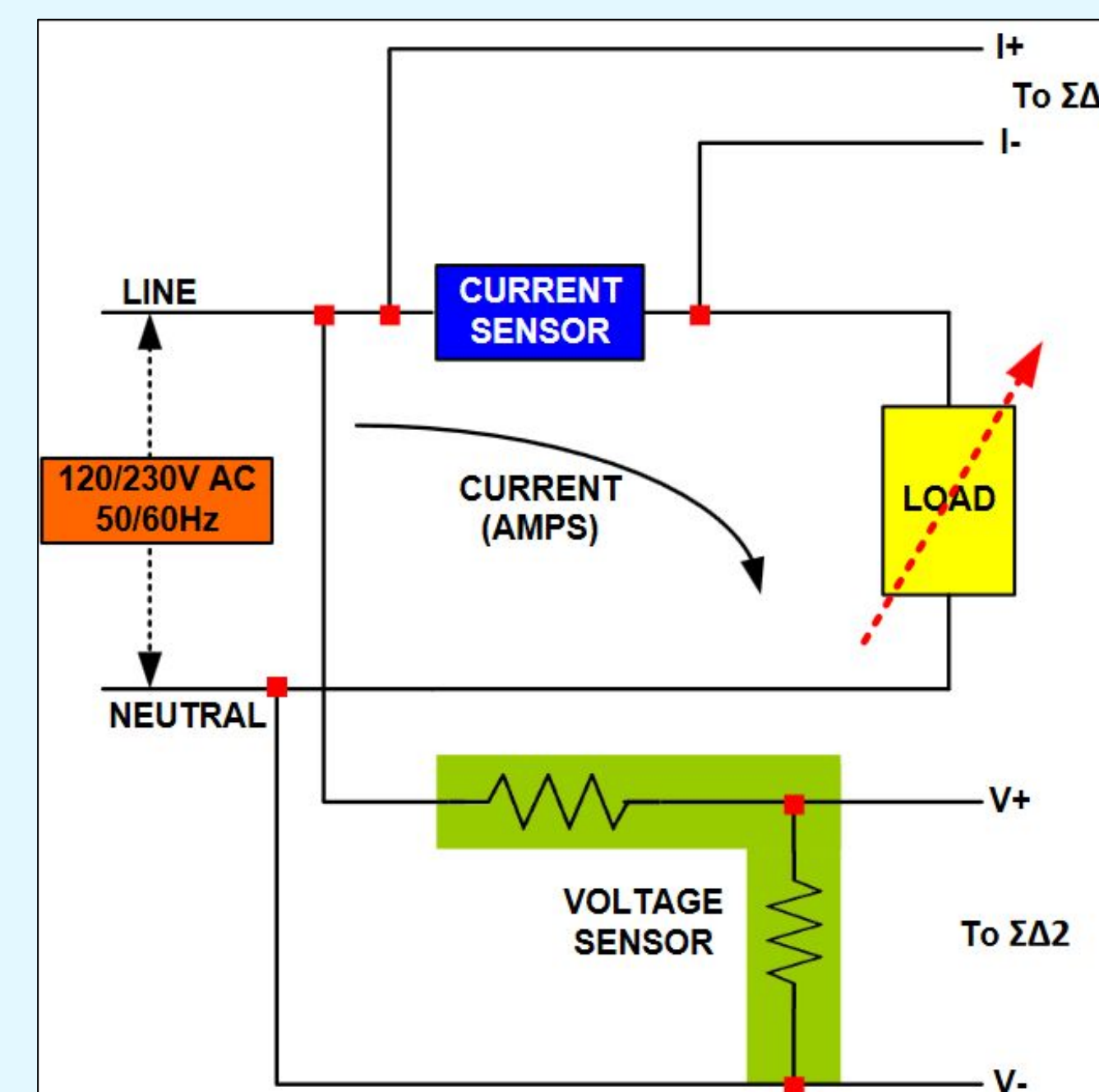


### Sensing and Communication

- PCBs communicate via I2C for data transfer and outlet control.
- Outlet current and voltage data are collected by 24-bit Sigma Delta ADCs at a rate of 1.8 kHz.
  - Per-outlet data sent in 2 kB buffers to master MPU for RMS calculations.
- Toggle commands are sent asynchronously.

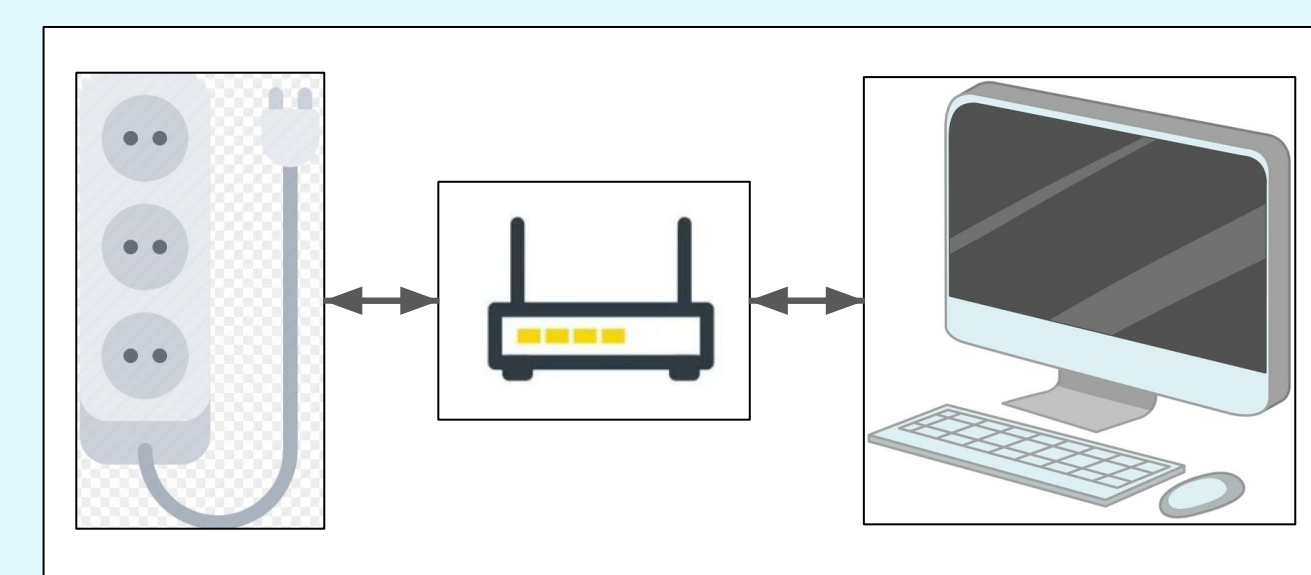
$$V_{RMS} = \sqrt{\frac{1}{N} \sum_{i=1}^N V_{samp}(i) * V_{samp}(i)}$$

$$I_{RMS} = \sqrt{\frac{1}{N} \sum_{i=1}^N I_{samp}(i) * I_{samp}(i)}$$

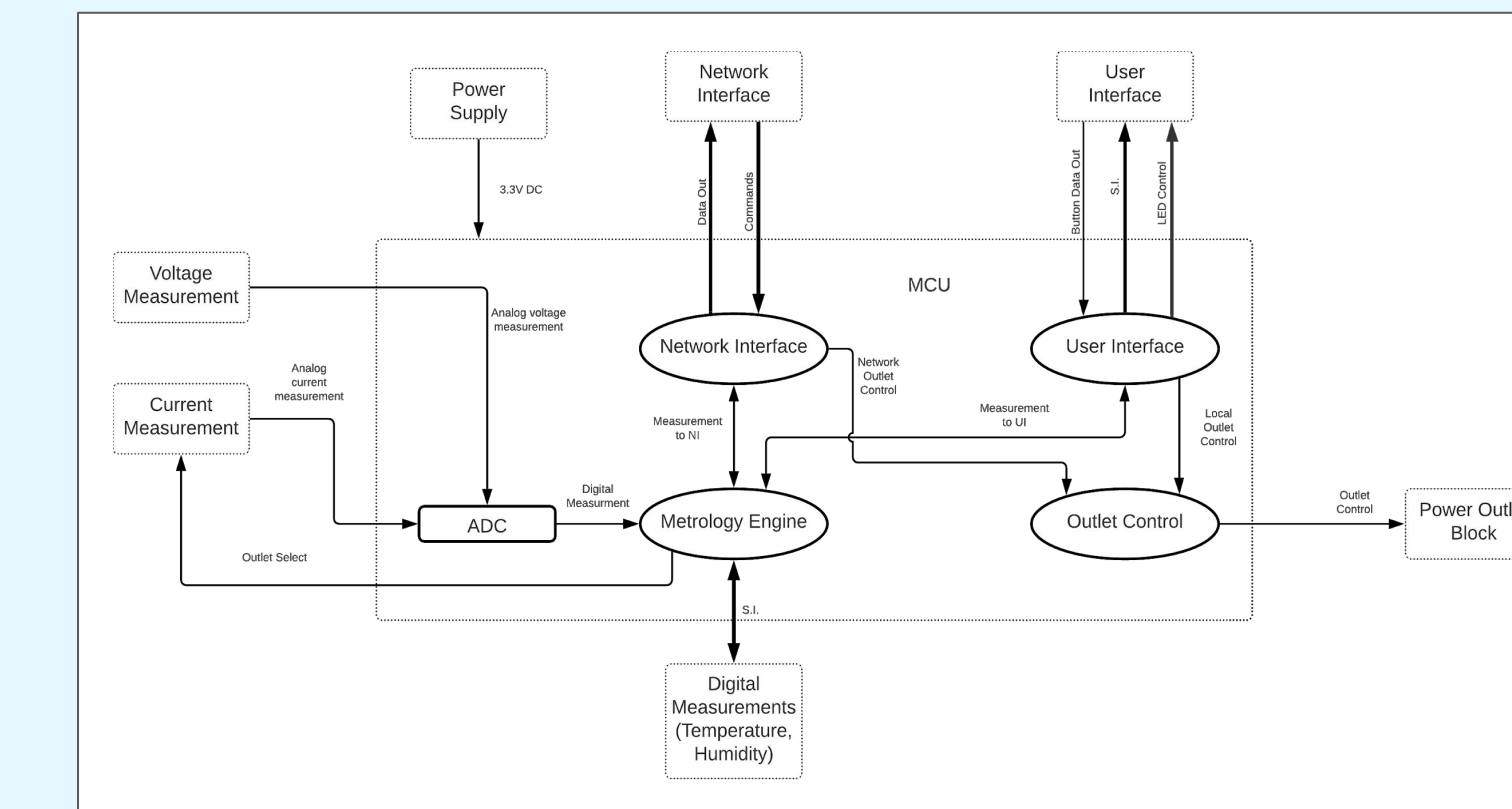


### Communications and Server

- PDU communicates with client PCs on a local area network (LAN).
- PDU plugs directly into router via Ethernet.
- Website hosted on local server in vicinity of PDU.
  - SQLite database
  - Detached PDU synchronization for multi-PDU/multi-client utility.



### Driver Board

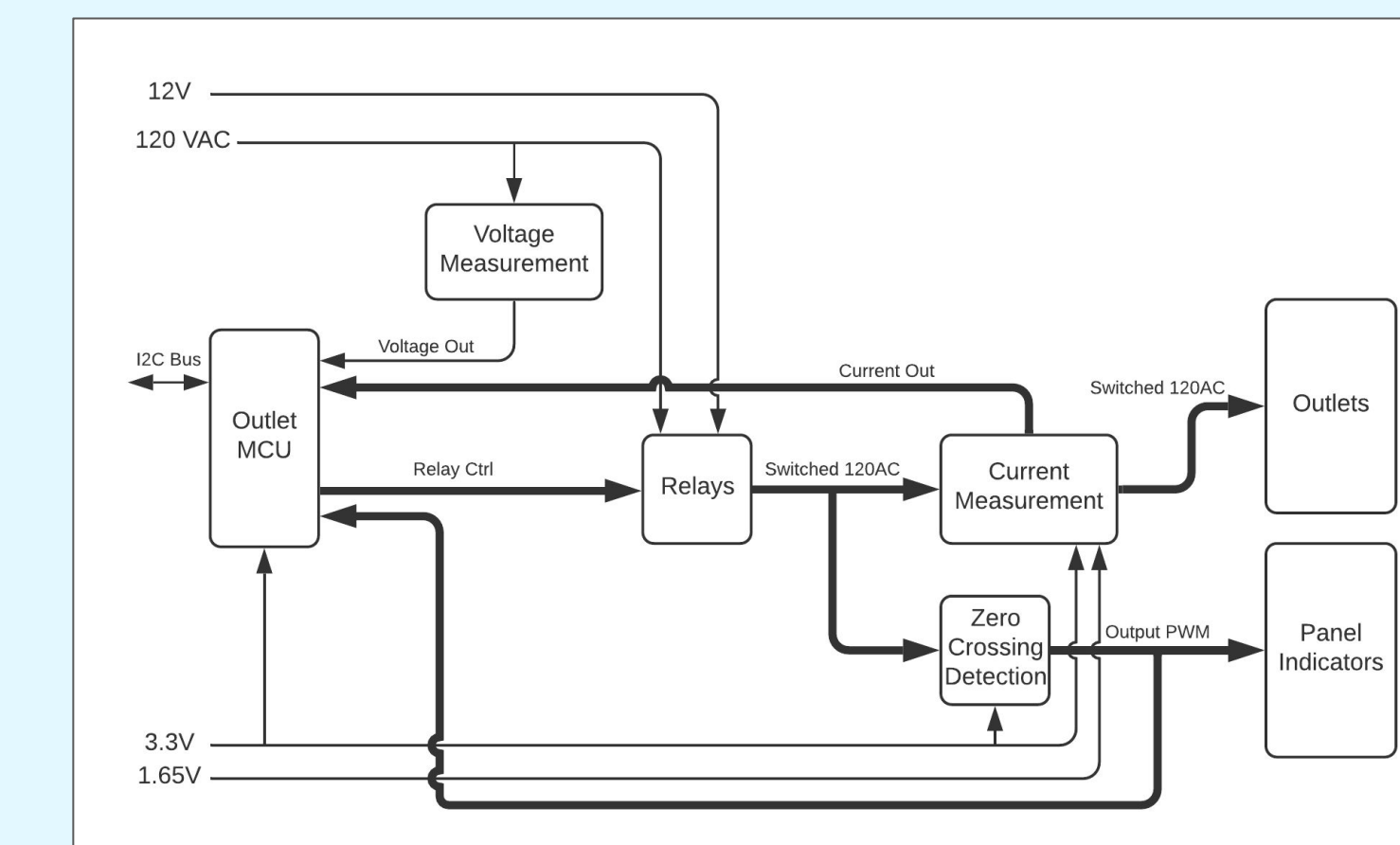


- User Interface**
- LCD parallel interface
    - Displays telemetry data on LCD and system state
  - Button GPIO interface
  - Necessary for work in non-networked environments
- Outlet Control**
- Turning individual outlets on/off
  - Serial interface to outlet controllers (I2C)
  - Necessary for power management and security
- Metrology**
- Handles temperature, humidity measurement
  - Receiving information about current, voltage sensing

Coordinate PDU subsystems

- Interfacing with LAN
- Interfacing with User
- Receives commands/sending data
- Sending commands/receiving data from subsystems
- Logic: TI MSP430F5529

### Outlet Control and Measure



Outlet control and measurement is split into two separate PCBs, one which houses the digital logic (outlet control board), and the other handles all high current devices (relay board).

Outlet Control Board

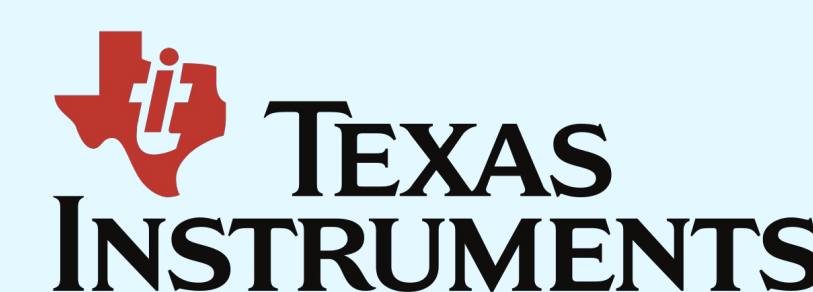
- Voltage and current sampling with MSP430i2040 onboard 24-bit Sigma Delta ADCs
- Relay drivers for outlet control
- Outlet status detection and indication (LED front panel indicators)
- I2C for data transactions

Relay Board

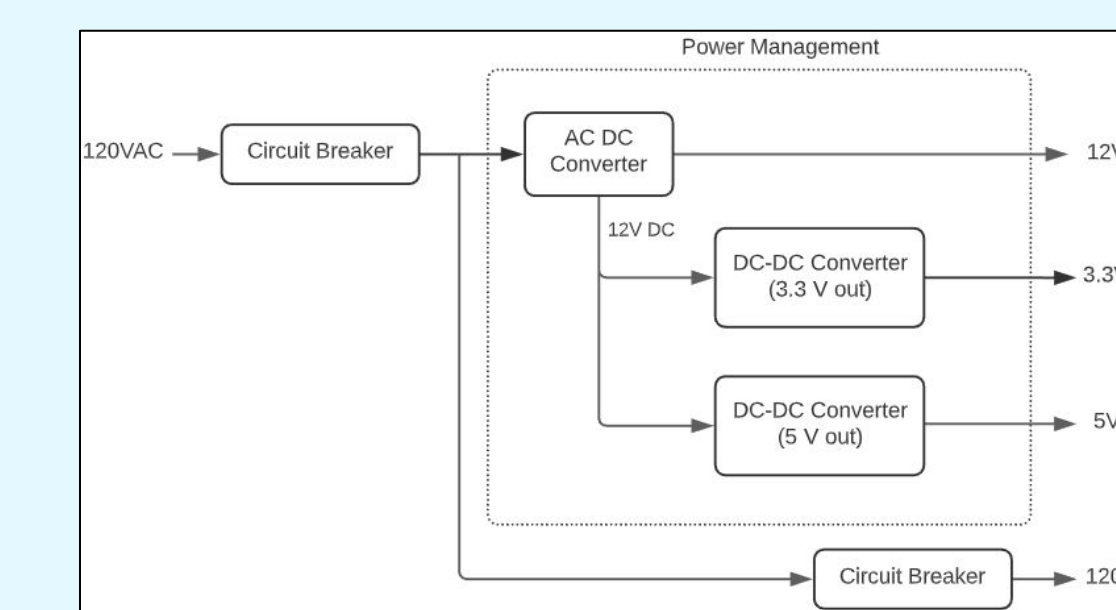
- Relays control power flow to outlets
- Hall effect sensors for current measurement with differential gain stage
- Voltage attenuation for voltage measurement
- Outlets can supply up to 16A RMS
  - Full custom board with 4oz copper

### Acknowledgements

Thank you to Professor Femrite and our TA Jake Perez for working with us throughout the project. We would also like to thank Eddie Garcia, Jackson Chong, Kelvin Lee, and Angel Garcia from AGM, Steve Dunbar from Texas Instruments, Zachary Lefin from Horizons, and Sean McKee from CET for all of the help throughout the project.



### Power Delivery Board



- AC to DC Conversion with 4 Outputs:
  - 3.3V for Driver Board
  - 5V for LCD
  - 12V to control relays on outlet board
  - Ground line